

Optimising the intestinal health of poultry with butyrate supplementation

Modern poultry production has undergone dramatic changes over the last 50-60 years: genetic selection for high growth rates as well as improved management and nutrition strategies, have led to increased performance standards.

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Havenstein et al compared the male Ross 308 broiler from 2001 with a male heritage broiler strain (ACRBC) from 1957, both fed 2001 diets in order to evaluate the effect of genetic selection (Table 1).

At 42 days, the Ross broiler fed a 2001 diet reached a final weight of 2903g with a FCR of 1.58; while the heritage strain obtained a final weight of only 641g with an FCR of 2.05. However, in the near future, animal performance could reach a ceiling due to genetic and physiological limits. As the intestine is the most important organ to convert feed into meat, it is no secret that 'gut health' has entered the collective consciousness and has become the standard of the poultry industry and research.

Butyric acid, role in the gut

A lot of research has been conducted to identify the role of the gut: risk factors, as well as some key

Parameter	Strain	
	Ross 308 (2001)	Heritage strain (1957)
Body weight	2903	641
FCR	1.58	2.05

Table 1. Cumulative FCR and final body weight of male Ross 308 versus a male heritage strain (ACRBC) fed a 2001 diet (Havenstein et al, 2003).

molecules supporting intestinal health, have been determined.

A key molecule boosting gut health is butyric acid. Butyric acid (C4) is a short chain fatty acid (SCFA) with a biological role consistently present in the intestinal ecosystem, as it is naturally produced by fermentation of polysaccharides by the intestinal microbiota. The role of butyric acid in the gut can be briefly summarised by the following actions: promotion of the intestinal barrier, modulation of the immune system, balancing the intestinal flora and improving digestion and absorption of nutrients, leading to enhanced performance in poultry production.

These actions meet the three pillars of gut health: microbiota, intestinal lining and immunity.

1. Promotion of the intestinal barrier

Several studies have indicated that butyrate increases epithelial cell proliferation and differentiation on the one hand and inhibits epithelial apoptosis on the other, resulting in

longer villi. Butyric acid is the main energy source for the colonocytes. Entero-endocrine L-cells, part of the intestinal lining, react to butyrate by GLP-1/2 (glucagon like peptide) secretion, regulating different (extra-)intestinal physiological processes, like villi growth over the entire GI tract, insulin secretion, nutrient absorption, etc. Second, butyrate regulates the assembly of tight junctions, resulting in a stronger intestinal barrier.

2. Modulation of the immune system

The immune system is one of the most crucial and complex systems of the body. On one hand, it has to protect the chicken against harmful invaders, but on the other hand, an over reaction of this system implies a waste of nutrients, which will reflect on performance results.

One ingredient which has the ability to direct the immune system to a status of protection and not over reacting is butyrate.

Butyrate is known to stimulate the specific (acquired) immunity by T-

helper 2 stimulation and to prevent the non-specific (innate) immunity from overreacting by T-helper 1 inhibition. T-helper 1 inhibition by butyrate is established through decreased secretion of the pro-inflammatory mediator, IL-12, by the antigen stimulated macrophage.

In addition, butyrate has the ability to induce colonic regulatory T-(Treg) cells which have a central role in the suppression of inflammatory responses.

3. Balancing intestinal flora

One of the characteristics of a healthy gut is defined by a well-balanced microbiota. Professor Collett, Georgia State University, has developed a program 'how to maintain a healthy gut', which is based on three pillars: Seed, weed, and feed.

Seed the gut with favourable organisms, weed out the undesired pathogens, and feed the favourable intestinal microflora to ensure rapid domination. Butyric acid plays a central role in this program.

Butyric acid is produced by fermentation by the beneficial microflora, for example by Clostridial cluster IV, XVI and XIVa&b, starting from carbohydrates entering the gut.

The microflora of the broiler chick is recently described by different authors: the ileum is predominantly colonised by Lactobacillae, while the caecum is predominantly colonised by Clostridiaceae.

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Fig. 1. Average daily gain of broilers was significantly improved by supplementation with Butifour F.

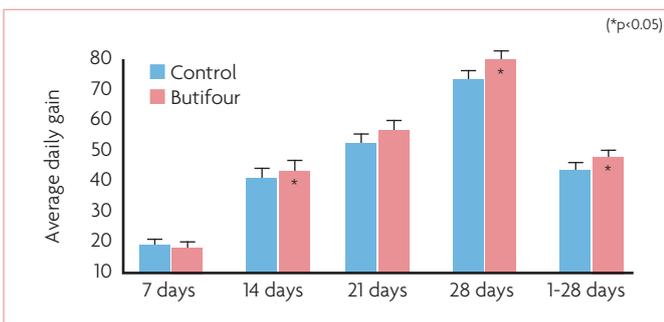
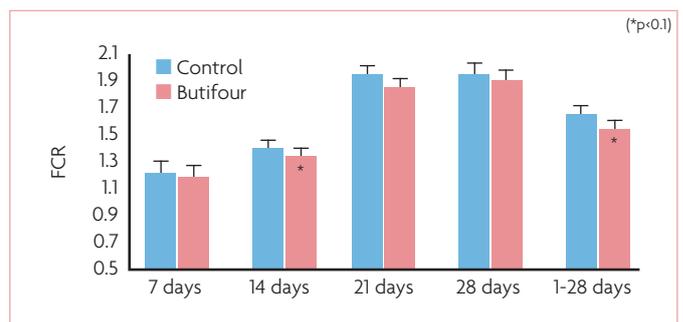


Fig. 2. FCR of broiler chicks was significantly improved by supplementation with Butifour F.



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It is obvious natural production of butyrate is established in the large intestine. The mucosa associated microbial community consists of butyrate producing microflora, mucin degrading bacteria, enterobacteriaceae and clostridia: it is no coincidence butyrate production appears in the proximity of epithelial cells and in close association with invading and histotoxic pathogens.

Butyrate has a specific action against salmonella as it is decreasing HliA and InvF expression, both regulators of the salmonella pathogenicity island, decreasing attachment to and invasion of the epithelial cell lining. Lesion induction in case of necrotic enteritis linked to a *Clostridium perfringens* infection is inhibited by butyrate.

4. Improving digestion and absorption of nutrients

Efficient nutrient digestion and absorption is the key for an optimal performance. The final step in digestion of dietary carbohydrates and proteins occurs right on top of small intestinal enterocytes. The enzymes responsible for this terminal stage of digestion are tethered in the plasma membrane of the

enterocyte, composed of numerous microvilli which extend from the cell and constitute the 'brush border'. Hence, the enzymes embedded in those microvilli are referred to as brush border enzymes. As butyrate stimulates villi growth, this brush border will be expanded and enzyme activity will be enhanced. Apart from that, the absorptive surface will be enlarged and nutrients will be absorbed efficiently.

Use in poultry production

Butyric acid as such cannot be supplemented to poultry feed due to its volatility and pungent odour.

Solutions were developed by the industry: supplementation of coated salts of butyric acid – butyrate – became a standard. Other ingredients for example specific acid salts and natural extracts have proven to interact synergistically with butyrate and are thus enhancing butyrate's action (Impextraco internal research).

Butyrate supplementation in poultry production can be translated in enhanced production. In broiler production improved growth and feed efficiency can be observed. Less diarrhoea, less salmonella and clostridia problems are noted. Butyrate supplementation in layers

	Butyrate	Control	p-value
Villi length	1254.36 ^a ± 126.14	1150.30 ^b ± 143.96	0.0011

Table 2. Histological evaluation of jejunum of 39 day old Ross 308 broilers supplemented with a butyrate based product (Butifour F) (0-39 days) (Impextraco internal data, not published).

became a standard as improved egg shell quality (less dirty, broken and cracked eggs), and improved laying rate leading to more eggs are clearly observed. Gut health issues like necrotic enteritis and salmonella infections are kept under control. The effect of butyrate based products in breeders are similar to layers. Due to better eggshell quality and improved lay, an improved hatchability with more day old chicks are obvious.

A 28 day trial was conducted at the Catholic University of Leuven, Belgium with 64 individually identified Ross 308 broiler chicks housed in 16 pens.

Standard diets were formulated according to bird age: starter feed (0-14 days) and grower-finisher feed (15-28 days).

Chicks were divided into two treatments: control (standard feed) and a butyrate based group (standard feed + 750g of Butifour F per ton of feed in starter period and 500g/ton of feed in the grower

period) (see Figs. 1 and 2). Feed conversion ratio (FCR) and daily weight gain (ADG) were calculated afterwards, based on feed intake and broiler weights respectively. Average daily gain and final weight were significantly improved by butyrate supplementation. FCR was significantly improved.

Conclusion

The advantages of using butyrate based products are proven in university as well as in field conditions. The mode of action of butyric acid is well documented in literature but a lot of research still has to be performed to discover detailed working mechanisms.

To conclude, butyrate based products have proven their efficiency for years and have become a standard in poultry production. ■

References are available from the author on request